the earth, curving sharply in at the poles in the classic lines of force of a dipole magnet. In its lower reaches it overlapped the ionosphere, but its radiation was quite different from and many orders of magnitude more intense than that of the ionosphere. The intense component in the inner belt, reaching a peak at about 2,000 miles, appeared from early measurements to be mainly high-energy protons (hydrogen nuclei stripped of electrons); in the outer belt, peaking at about 10,000 miles, it seemed to be mainly high-energy electrons.

Less well known is the story of how this picture has changed with later satellite exploration. There are not two Van Allen belts, as was generally believed, but only one of huge dimensions, though the terms inner and outer zone remain in use. And the zonal distribution of particles is much more complex (see diagram on pages 120 and 121) [not printed in RECORD] than originally appeared. The flight of Explorer 12 in 1961 overturned the neat zonal divisions by finding that the outer region contains an important number of low-energy protons, as well as electrons, thus indicating that a more realistic picture of the belt would be a regional overlay of high- and low-energy protons and electrons. At the same time the symmetrical concept disappeared with the discovery by Explorer 10 that the belt extends out much farther from the dark side of the earth than from the light. This is caused by a steady "wind" of particles from the sun that compresses it on the sunlit side and blows it out in back—perhaps as much as 100,000 miles or more.

In this enormous area many conundrums remain. One theory is that radiation-belt particles come from two main sources: in the outer zone, from particles streaming in on solar flares and the relatively constant solar wind; in the inner zone, from cosmic-ray reactions with atmospheric atoms, producing secondary protons and electrons and accounting for the very high-energy radiation at this level. But exactly how solar particles get into the strong magnetic field is still a question. And how the particles, once trapped, maintain themselves and accelerate in energy is still unclear. Complicating the problem is the fact that the field constantly loses electrons to the atmosphere or to outer space, in greater or lesser amounts, by processes not yet known but suspected of having effect not only on the ionosphere but on the weather below. How long, on the average, particles remain in the belt is therefore an important question, to which a recent experiment gave some startling answers.

THE WORLD'S BIGGEST UNCONTROLLED EXPERIMENT

On July 9, 1962, the U.S. Department of Defense and the Atomic Energy Commission exploded a 1.4-megaton nuclear bomb 250 miles above Johnston Island in the Pacific in an experiment code-named Starfish. The military purposes, of course, were never divulged. There was speculation, however, that these revolved about the study of blackout—i.e., the possibility of paralyzing a nation's defenses by blacking out communications, control systems, and missile-guidance mechanisms with radiation from a high nuclear blast. Riding along with this was a scientific experiment designed to study any artificial radiation belt created by the blast. A series of smaller tests high over the South Atlantic in 1958, called Argus, had had some interesting though short-term results. But the Starfish burst went beyond most expectations.

Within seconds, flashing auroras appeared 3,000 miles away in the night skies over Samoa and New Zealand. The floor of the ionosphere's D region precipitously dropped nearly 10 miles, under intense ionization, disrupting all radio communications in the Pacific area. The whole magnetic field shook violently around the world. Within 6 minutes, a big radio-telescope antenna 6,000 miles away in Peru registered a nearly tenfold jump in background noise. Within a month, three satellites were knocked out—Ariel, temporarily, Transit 4-B, a navigational satellite, and Traac, a scientific vehicle—by radiation poisoning of solar cells. Others had their life spans greatly reduced by radiation damage. But two satellites—Injun 1, launched with instrumentation by Van Allen's group a year before, and Bell Telephone Laboratories' communication satellite Telstar 1, launched a day after the blast—operated long enough to monitor the initial radiation from two heights. The explosion shot an enormous jet of electrons to unexpected altitudes, where they were trapped. It is estimated that over 10,000,000,000,000,000,000,000,000 electrons were injected into the belt, of such intensity that they could easily be detected above the natural electron flux. While most of the immediate, spectacular effects swiftly subsided, there remained this new belt of dangerously high radiation coiling within the old belt around the earth.

Controversy had flared before the test, when groups of United States and European scientists protested its dangers and uncertain consequences. There was even more bitter controversy afterward over how long the new radiation would remain. Van Allen's group, which had gone along with the test and monitored it at low altitudes, maintained that the new belt would disappear by absorption in the atmosphere within a year; others, led by NASA's Wilmot N. Hess, leaning on Telstar and other satellite measurements higher up, estimated that it would last much longer. As in many scientific controversies, both proved right, but not to the same degree. At low altitudes the new radiation was quickly dispersed in the atmosphere, and at high altitudes it disappeared, through magnetic fluctuations, into space. This was proved, ironically enough, by a series of three, equally strong, high-altitude Russian tests that apishly followed Starfish some 3 months later. Because the Russian shots injected particles into the belt from very high Siberian latitudes, where the highest magnetic lines of force bend down toward earth, most of their radiation was carried into the lowest and highest regions of the belt, where it was soon dissipated. But most of Starfish's intense radiation, injected from equitorial latitudes, wound up at the more stable, intermediate altitude of 1,000 to 2,000 miles, where it hung on.

Late in 1962, Van Allen finally concluded from further data that the artificial belt of electrons is likely to last 10 years. And results are now in from Explorer 15, sent up specifically to measure the new belt, and its data shows that if the electrons follow their present observed rate of decay "it will be possible to detect their presence among the naturally trapped particles for at least 20 years." This may be shortened during the next peak of solar activity, due about 1968–69 on its regular 11-year schedule, when big solar flares may tend to flush out electrons. Meanwhile the flux remains intense enough to constitute a real, additional radiation hazard to men and equipment. An astronaut at about 1,000 miles up, with maximum practical shielding, would receive about 25 roentgens an hour. A total of about 100 are enough to cause violent nausea and radiation sickness, and an accumulation of 500 is lethal. "It is not a region in which to sit or linger," says Wilmot Hess.

On the credit side, the experiment has brought in more knowledge more quickly than possibly any other device concerning the probable life cycle of particles in the belt. And this knowledge is spurring the military, NASA, and industry to develop more radiation-resistant equipment. But scientifically the test was an uncontrolled experiment of awful proportions. So little was known before the test about the natural radiation belt that the study of its properties may now be obscured for years by the artificial belt. And militarily the test may prove simply that radiation blackout, like its progenitor, the bomb, is a weapon as likely to knock out its users as its victims. Repeated high-altitude bursts of even bigger bombs could easily create a belt many thousand times more intense than the present one, bringing an end to the reliable operation of all scientific, weather, communication, navigation, and other satellites, and endangering all space exploration. There was therefore more than one reason why last summer's test ban treaty included an agreement to keep nuclear explosions out of space.

WINDS THAT "BLOW" 1,000 MILES PER SECOND

Any premature end to space exploration would be high tragedy, for only now, beyond the radiation belt, instruments are beginning to yield answers to some of the age-old secrets of the sun and earth and planets, and of the interplanetary medium that joins them.

Explorers 10 and 12, besides measuring the earth's magnetic belt, made the first detailed observations of the solar wind—a plasma of hot, highly attenuated, ionized gases composed of protons, electrons, and helium nuceli—flowing in steadily but variably at gentle cosmic speeds of 200 to 500 miles per second. Now and again this wind is whipped to velocities of 1,000 miles a second or more by solar flares—long, intensely hot tongues of plasma, distantly observed for decades, leaping from huge explosions on the sun in bright sunspot areas. Rocket probes and satellites have now been sent into the area of flares to measure them directly. In major flares, their data shows, a large chunk of the sun's substance is ripped out, carrying with it an actual portion of the sun's magnetic field. This acts as a gigantic magnetic "bottle," conducting the hot plasma streaming out into space, and occasionally detaching itself from the sun as a giant, self-contained plasma cloud. This plasma moves upon the earth at supersonic speeds, preceded by an enormous shock wave, battering and compressing the radiation belt, sending magnetic disturbances down through the ionosphere into the earth.

The radiation accompanying such flares is the single greatest hazard in space. There is as yet no really good protection against the biggest flares. Fortunately, they occur infrequently, only once or twice a year at the height of sunspot activity; unfortunately, they are also highly unpredictable. Hence much more needs to be known about the behavior of the sun, quite aside from advancing pure knowledge, so that spacemen can be warned in time to adjust flights, take evasive action, or escape back to earth. Up to now, nothing noted on the sun has given sufficient warning time. But NASA's orbiting solar observatory, launched in 1962, turned up a hopeful clue. Preceding some larger flares by a few hours was a series of tiny microflares, never observed before. A close watch of these micoflares and other features may make it possible to predict the giant flares. Late last year NASA launched the first of a series of IMP's (interplanetary monitoring platforms) to orbit at a maximum height of nearly 200,000 miles and keep a constant watch on the sun.

A GREAT SORTIE INTO THE SOLAR SYSTEM

Nearly all long-distance records for a satellite thus far were broken by Mariner 2, the space probe designed by California Institute of Technology's Jet Propulsion Laboratory and launched on a pass at Venus in December 1962. In 129 days of continuous operation and communication out to a record 53,900,000 miles from Earth, it transmitted back some 65 million bits of information, now stored on tape. Only the major peaks of this mountainous pile of data have so far been analyzed.

On its way out, Mariner 2 confirmed the solar wind at great distances. It affirmed the concentration of cosmic dust near earth, finding it 10,000 times denser than farther out. Only two meteoroid hits of any significant size were registered on the whole journey. And it found that the entire radiation dosage on the trip was much less than expected, only about three roentgens. It would have been a good year for manned space flights.

Some 22,000 miles from Venus, at a signal from earth, Mariner turned its microwave and infrared scanners on the high, impenetrable clouds of that mysterious planet. Instruments registered a surface temperature on Venus of some 800° F., no detectable water vapor, and no cosmic dust in its vicinity. The planet had almost no apparent rotation and no magnetic field—hence nothing to shield it from intense solar flares. It appeared to be a dead and stifling world under the greenhouse effect of its dense cloud cover, speculatively a smoglike mixture of hydrocarbon gases. This confirmed some theories about the planet and severely jolted others. Twenty days later Mariner departed into a silent, eternal orbit around the sun.

Late this year another Mariner will probe around Mars, where the possibility of finding conditions more favorable to some form of life is greatest. Also scheduled is a series of Surveyor flights to the moon, from which the United States has been less successful than the Russians in getting back data. Meanwhile, the whole program is moving from small satellites, each fitted to a single mission, to big, advanced, flying-boxcar satellites, crammed with 20 to 50 sets of instruments for broad-scale attacks on big areas. Starting with the orbiting solar observatories (to probe the Sun and all solar plasma phenomena), this new generation will include a series of orbiting geophysical observatories (for the upper atmosphere, radiation belt, and magnetic field), and, as a crowning effort sometime in 1965, the first Orbiting Astronomical Observatory (for stars and galaxies). The whole series is aimed at a methodical look at the whole solar system and intergalactic space. An understanding of the origin and workings of the solar system should go far to solve some of the deeper problems of galactic space, where only recently the great radio telescope at Jodrell Bank, England, has measured magnetic fields between the stars, associated with great clouds of hydrogen and dust, much like the plasma connecting Sun and Earth.

BIG BANG OR STEADY STATE

Beyond the solar system, rocket probes and satellites so far have brought in only a few tantalizing hints of greater discoveries to come. A series of probes has shown, for instance, that hot stars are putting out less ultraviolet radiation than previously calculated; less by as much as 30 to 40 percent. If the measurements are not being shrouded by dust clouds or other factors, this means that the stars are burning hydrogen much more slowly than was thought and the whole scale of stellar evolution may have to be revised.

Another series of probes, capped by Explorer 11, turned up what may be a key bit of evidence in determining the origin of the universe. There are two well-known theories. The leading one is the big bang theory, in which it is postulated that the universe began at a finite point in time, some millions of years ago, with the explosion of a gigantic, dense, primordial atom, creating all the present elements, stars, and galaxies. This is inferred from the strongest cosmic evidence thus far, that all the galaxies are observably receding from one another at tremendous speeds as if from that original explosion. The second theory, called the steady state, infers that the universe has no beginning or end but is continually creating new hydrogen between the stars to replenish the disappearing galaxies. The new rocket findings show, however, that there are many fewer gamma rays in interstellar space than there should be if hydrogen is being created continuously. Hence the newest findings tend to support the big bang theory against the steady state.

More recently, a series of rocket probes has made another big discovery in one constellation of our own galaxy. This is a huge source of X-rays, undetectable from earth, about 1,000 times more intense than those from the sun or any known stellar processes. In the most distant galaxies, radio telescopes have recently discovered other inexplicably huge sources of energy, greater than any thermonuclear processes so far known on earth. All this leads physicists to anticipate the discovery of entirely new principles for generating enormous amounts of power, and along with this, from further study of solar plasmas and other stellar phenomena, new energy transfer and conversion techniques. Meanwhile, more advanced ultraviolet, gamma, and X-ray instruments in the new orbiting observatories may well reveal other wholly new and perhaps revolutionary aspects of the universe.

Already being planned for advanced satellites are experiments to investigate some of the fundamental yet still largely mysterious underpinnings of the universe, such as the force of gravity and the speed of light, the great universal constant that is the linchpin of modern physics.

IS MAN LOST IN SPACE?

Ultimately, of course, and sooner than the word implies, men will go out there to observe, experiment, and see for themselves. As great and ingenious an advance as space instruments are, they still observe the universe at many removes. Much of the data they send back is equivocal, open to various interpretations, or just plain inconclusive. And no instrument can be designed to cope with all possible unknowns. Even so eagerly awaited an advance as the orbiting astronomical satellite is still a highly unstable platform from which to view the stars. It is subject to perturbations, hard to aim or keep on targets, and its telescopic pictures are degraded by television transmission back to earth. Once astronomers are carried in satellites, it should be a great improvement, for there is no substitute at a telescopic eyepiece for the astronomer's direct vision and control.

But even then, the artificial satellite is not an ideal platform, for every slightest movement of the astronomer will cause an equal and opposite movement of his weightless observatory. And even an orbiting space station—the much larger, more permanent type of manned satellite being proposed by some—would have the same defect, plus the additional disadvantage that, in order to make it habitable for extended periods, it will probably have to be spun to give it some measure of artificial gravity.

But there is nearby a natural satellite—the moon—that is an almost perfect space platform. It is big and solid. It has almost no atmosphere to speak of and just enough gravity to make it possible easily to erect huge, stable structures, such as telescopes, radio, and radar facilities. From these astronomers will be able to view the universe more directly, through fewer intervening systems and hindrances, than ever before. Hence, despite recent political pulling and hauling, there are many sound scientific reasons, as well as others, for getting men to the moon. And this will be done, for it is the master key to all future exploration of space.

The purposes of this exploration are no clearer to many men in this age than they were in Galileo's, so it is not strange that there is opposition. In this economic age, however, the opposition is not so much theological as budgetary. Both seem equally mistaken in the context of their times, for the earlier astronomical discoveries did not diminish man's spirit but rather enlarged and ennobled it, and space discoveries should have the same uplifting and enlarging effect. After all, a budget is only money, but new knowledge is a dukedom whose great wealth and resources cannot even begin to be estimated or exhausted. Already the new knowledge acquired in space exceeds by far the value of funds so far spent. For knowledge, more than guns and butter, is the true power of modern states.

Cuba Is Guilty

Cuba

EXTENSION OF REMARKS

OF

HON. EDWARD J. DERWINSKI

OF ILLINOIS

IN THE HOUSE OF REPRESENTATIVES

Thursday, February 20, 1964

Mr. DERWINSKI. Mr. Speaker, in the excitement over the latest crisis at Guantanamo, we might tend to forget Castro's completely illegal and belligerent activities against other members of the Organization of American States.

An editorial in the Monday, February 17, edition of the Chicago Sun-Times, very properly reemphasizes the guilt of the Castro government in its aggression against Venezuela and most properly calls for severe and lasting sanctions. I insert the article for the Appendix of the RECORD:

CUBA IS GUILTY

According to reliable sources the five-nation, inter-American investigating team of the Organization of American States has finished its investigation and has found Communist Cuba guilty of aggression against Venezuela. The official report is due to be released shortly.

The OAS investigating team was made up of representatives from Uruguay, Costa Rica, Colombia, Argentina, and the United States. Their report is based on several pieces of confirmed evidence.

One such piece of evidence was the existence of documents showing that Cuba has trained more than 400 Venezuelans in guerrilla warfare in the past 2 years. There was, also, the evidence of some 3 tons of arms found on a remote beach in Venezuela. The arms were positively identified as having come from Cuba by means of serial numbers on record in Belgium, the source where Cuba bought the arms.

A raid by Venezuelan police on the home of a known Communist in Venezuela turned up documents outlining plans to capture the capital city of Caracas.

Under the terms of the 1947 Rio de Janeiro treaty of mutual assistance the OAS may now invoke one or more sanctions against Cuba. These sanctions include the ending of both diplomatic and consular relations, an economic blockade against Cuba or the use of outright armed force.

Such sanctions have been imposed in only one other case by inter-American action, that of a Venezuelan complaint against Trujillo in 1960. The sanctions of that time were severe; they consisted of a break in diplomatic relations, a partial economic boycott and the suspension of all trade in arms and war materials. The Trujillo regime collapsed a short time later.

What sanctions the OAS will impose against Cuba are not known. It is hoped, in some circles in Washington and Latin America, that they will be severe and lasting.